International Journal of Latest Technology in Engineering, Management & Applied Science (IJLTEMAS)
Volume VIII, Issue XI, November 2019 | ISSN 2278-2540

Suitability of Powdery Ceramic Tiles as Partial Alternate Ingredient of Ordinary Portland Cement in Concrete Production

Adeala A.J.[1*], Osore O.T[2]

[1]*Department of Civil Engineering, The Federal Polytechnic, Ilaro, Ogun State, Nigeria*
[2]*Department of Architectural Technology, The Federal Polytechnic, Ilaro, Ogun State, Nigeria*
**Corresponding Author*

Abstract: **Construction site is associated with the collection and disposal of wastes such as ceramic tiles and in order to minimize the landfill up in environment, the ceramic tiles was grinded into powder and used as partial substitute of Ordinary Portland Cement (OPC) in concrete. This study investigated the structural properties of powdery ceramic tiles concrete with graded levels: (0%, 5%, 10%, 15% and 20%) of powdery ceramic tiles. Wastes of tiles generated from construction sites were used to replace cement in the production of 1:2:4 mix concrete, at constant water-cement ratio of 0.5, cast in sets of twelve (12) each in 150mm x 150mm x 150mm moulds. The resulting concrete cubes cured for 28 days and tested for absorption, compressive strength and workability of fresh concrete were also carried out in accordance with BS1881, 1983.The result showed that the compressive strength at 28 day were 27.06 N/mm^2 27.42 N/mm^2, 27.42 N/mm^2, 28.77 N/mm^2, 21.02 N/mm^2 at 0%, 5%, 10%, 15% and 20% respectively. Regarding to the compressive strength values, it was observed that powdery ceramics tiles concrete at 15% replacement has 28.77 N/mm^2 compressive strengths at 28 days of crushing after curing. Workability and absorption properties of the powdery ceramic tiles concrete also exhibited the same trend with that of compressive strength. The cost of construction can be reduced by 15%, if 15% of weight of PCT is used as substitute for cement. The research concluded that PCT at 28 days possesses strikingly similar characteristics with normal concrete up to 15% replacement which can be used for normal weight concrete. Suitability of powdery ceramic tiles can be as partial alternative of ordinary Portland cement in concrete production for sustainability in construction.**

Keywords: **Compressive Strength, Landfill-up, Powdery Ceramic Tiles, Water absorption, Workability.**

I. INTRODUCTION

Concrete is comprised of Portland cement, fine aggregate, coarse aggregate, liquid and or pozzolans, and air (ShriHiren J. Chavda, 2015). In any construction industries, Concrete is one of the most common used as Construction materials. Aggregates being one of the components in the production of concrete its Characteristics are to provide a solid mass on hardening of the concrete. The functional requirement of aggregates is provide a rigid interlocks with cements being the binding agent in concrete, to prevent moisture rising from the ground through foundation walls, it gives the concrete strength and stability to resist the action of applied loads. In Nigeria today, the cost of Portland cement is increasingly due to the increase in cost of materials for the production of the cement. The grinding of the clinker produces cement powder which is still hot and this hot cement is usually allowed to cool before it leaves the cement works. Necessary test are carried out on the cement before it is bagged and dispatched[10]. The Portland cement serves as the binding agent in mortar and concrete production and in order to achieve an efficient and sustainable concrete. Regarding to the constructions of infrastructure projects such as good road network, Buildings, Bridges, Dams etc. In Nigeria the use of cement is ascending year after year. Such infrastructures projects consume large natural resources. In the study carried out, it was concluded that using ceramic wastes in concrete can solve several environmental problems [12]. Concrete with tile dust as partial replacement for cement has minor strength loss which can be negligible and there is remarkable decrease in compressive up to 30%.

II. BACKGROUND OF STUDY

The compressive strength of concrete containing 20% broken ceramic tiles at 28days was 26.38N/mm^2 (84% of normal) was desirable and can be used to produce for structural concrete [1]. According to [14] observed that there was reduction of 23.32% in compressive strength of 7days when of 10% ceramic waste was replaced by fine aggregates, but after that while replacing 20% there was increase of 5.48% and with 30% there was increase of 14.56% increases respectively in initial compressive strength with respect to normal concrete mix. The research carried out on compressive strength, water absorption in this study, (PCT) were used as replacement of cement in concrete. The replacements were up to 20% of PCT with cement at 5% interval. When Sodium silicate used as binder with cement, the setting time of cement get affected [11. Water gets dehydrated from the mix while testing initial & final setting time of cement but initial & final time fall as per specified in code. Construction sites are associated with collection and disposal of waste during construction and demolition of building such as waste ceramic tiles dumped and unused. In order to reduce the hazard caused by waste ceramic tiles posed on environment. This research provides a way for an alternative use of powdery ceramics tile waste as partial replacement of cement in concrete production.

III. MATERIALS AND METHODS

This research work encompassed both Field and laboratory work. The Field work required sourcing for aggregates (Sharp sand and granite) powdery ceramic tiles. The laboratory experiments were carried out in Civil Engineering Concrete Laboratory Federal Polytechnic Ilaro, Ogun State and Moshood Abiola Polytechic Abeokuta, Ogun State. Broken ceramic tiles collected from demolition of buildings in Abeokuta and Grade 30 of Ordinary Portland Cement of Dangote was used in this research procured from a major distributor shortly after the delivery of a batch. The fine aggregates were sourced from dealers in Abeokuta, Ogun State and the size was determined through sieve analysis. The coarse aggregates were obtained from a construction site in Ilaro town, Ogun State and the size was determined through sieve analysis. Portable water was used for both mixing and curing. The concrete mix design of 1:2:4 and water cement ratio of 0.5 for control and other mixes. The fresh concrete was cast in mould for purpose of testing and curing. Broken ceramic tiles were collected mainly from dealers at Abeokuta, Ogun state. Broken ceramic tiles waste was washed and sun dried in batches then hauled to a power grinding machine which transformed it into powder. The Powdery Ceramic Tiles (PCT) was sieved using a 75 microns mesh size in order to obtain the required particle distribution size of cement. XRF-test was conducted on PCT to determine the composition of oxides by inorganic geochemical analysis using X-ray Fluorescence Spectrophotometer and it was carried out in University of Ibadan.

Table 1: XRF Analysis of chemical composition of Powdery ceramic tiles

Chemical constituents	**Percentage Composition (%)**
SiO_2	68.0
Al_2O_3	17.5
Fe_2O_3	6.48
MnO	0.07
CaO	0.82
P_2O_5	0.57
K_2O	0.27
TiO_2	0.06
MgO	0.74
(LOI)	5.11
Total	100

Figure .1: Broken Ceramic Tiles (BCT)

Figure **2:** Powdery Ceramic Tiles (Before Sieve)

Figure 3: Powdery Ceramic Tiles (After Sieve 75µm)

It was observed from the X-Ray Fluorescent test in accordance to [2] that the powdery ceramic tiles belong to class F pozzolanic because it has 91.98% of SiO_2, Al_2O_3 and Fe_2O_3 which is greater than 70% minimum silicate in class F in accordance with [2].

Table 2: Batch Weight of materials (kg) for each mix

	Mix I(0%)	Mix II (5%)	Mix III(10%)	Mix IV(15%)	Mix V (20%)
Cement	14.3	13.58	12.87	12.15	11.44
F.A	28.6	28.6	28.6	28.6	28.6
C.A	57.2	57.2	57.2	57.2	57.2
PCT	0	0.72	1.43	2.13	3.00
Water	7.15	6.90	6.44	6.08	5.72

Concrete cubes were cured and compressive were carried out on cured cubes at 7, 14, 21 and 28 days. Also 28 days water absorption tests were carried on concrete cube. Cube (150mmx150mmx150mm) were tested for engineering properties in accordance to [9, 7, 8 and 5].

IV. RESULTS AND DISCUSSIONS

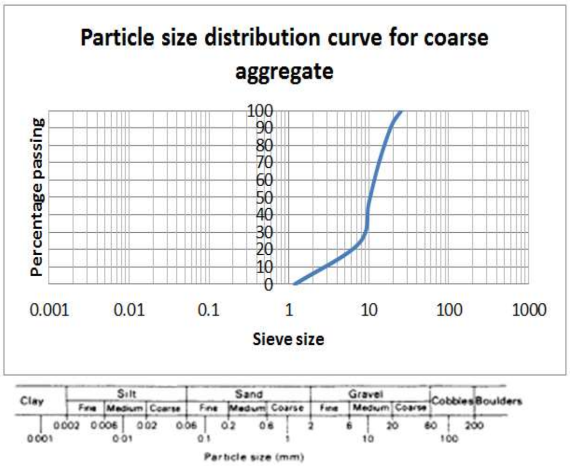


Figure 4: Particle size distribution curve for coarse aggregate (granite).

From the curve above,

Uniformity coefficient (C_u) = D_{60}/D_{10}

$C_u = 13/3 = 4.3 > 3$ (well graded)

Coefficient of gradation (curvature) Cc = $(D_{30})2/D_{60}*D_{10}$

$C_c = 9^2/13*3$

= 2.08 (well graded)

Interpretation: Coarse aggregate was well graded because values of C_u and C_c lied within range in accordance to BS 1377-2:1990

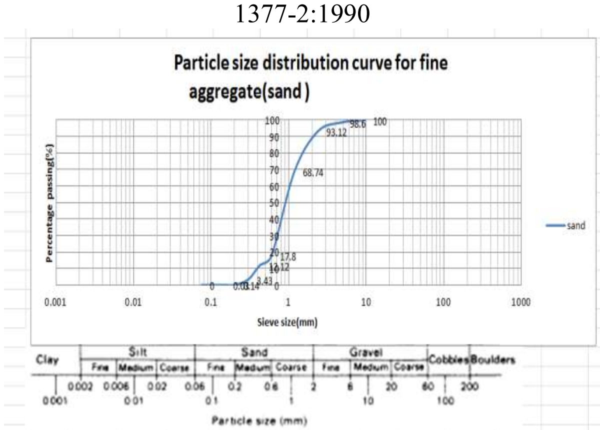


Figure.5: Particle size distribution curve for fine aggregate (sand).

$C_u = 1.0/0.4 = 2.50 < 3$ (uniform)

Where C_u is the coefficient of uniformity.

Coefficient of gradation (curvature) Cc = $(D_{30})^2/D_{60}*D_{10}$

$C_c = 0.7^2/1.0*0.4$

= 1.23 lies between 0.5 and 2 (well graded)

Interpretation: Fine aggregate (sand) was uniformly and well graded because values of Cu and Cc lied within range in accordance to [6]($1< C_u <3$) and ($0.5< C_c < 2$).

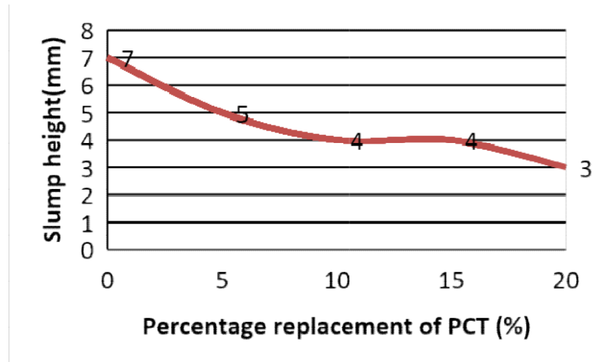


Figure 6: Slump against percentage replacement of PCT.

The control specimen has slump height of 7mm and decreased to 5mm with 5% replacement of Powdery Ceramic Tiles, at 10% replacement of PCT reduced to 4mm slump and maintained the same slump value at 15% and finally decreased by slump of 1mm at 20% replacement of PCT.

It was observed that the higher the powdery ceramic tiles in concrete the less workable the concrete. It is because the hydration rate decreases as the powdery ceramic tiles increases in concrete.

Table 3: Density of concrete cubes at 28 days

PCT%	Weight (kg)	Density (kg/m³)
0	8.17	2420
5	8.36	2477
10	8.07	2391
15	7.99	2367
20	8.13	2409

5% replacement of PCT it increased to 2477kg/m3 Control specimen has density of 2420kg/m^3, and at and declined to 2391 kg/m3 at 10 % replacement then reduced in the same trend to 2367 kg/m^3 at 15% and finally accelerated to 2409 kg/m^3 at 20%. Concrete composed of 5% to 20% Powdery Ceramic Tiles(PCT) possessed standard unit weight of normal weight concrete 2400kg/m^3 because densities of concrete with Powdery Ceramic Tiles fallen within the range .

Table 4: Average compressive strength development with curing days and varying percentage of PCT.

Days/ Percentage	0	5	10	15	20
7	20.84	24.8	17.75	17.75	17.00
14	22.67	26.3	25.00	20.5	18.04
21	23.07	24.88	25.79	27.14	20.00
28	27.06	27.42	27.42	28.77	21.02

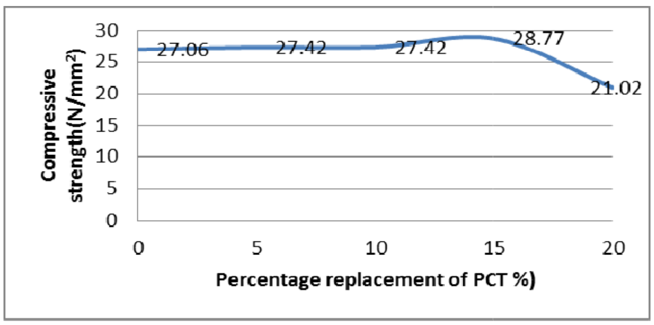
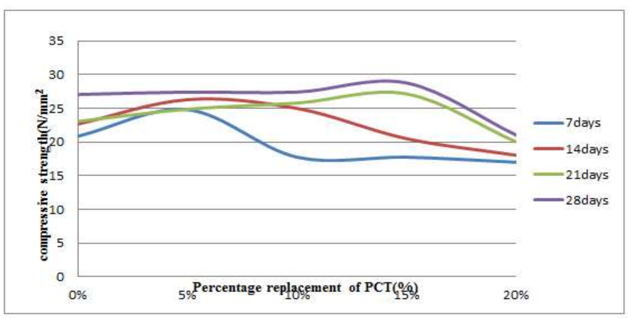


Figure 7: Compressive Strength development at 28 days against powdery ceramic tiles.



.

Figure 8: Compressive strengths development with the curing days.

The Compressive strengths development with curing days 7,14,21 and 28 days are shown in table 4 and figure 5.

It was depicted that there is approximately constant compressive strength of 27.42N/mm^2 between 5% and 10% replacement of PCT concrete and at 15% it was accelerated to 28.77N/mm^2 then decline at 20% to 21.02 N/mm^2.

According to BS 8110-1-1997, stated that for normal aggregate concrete, the minimum compressive strength is 25N/mm^2, which means coarse aggregate (granite of 19/20mm size) can be substituted between 5% and 15% of powdery ceramic tiles to have minimum compressive strength of 25N/mm^2.

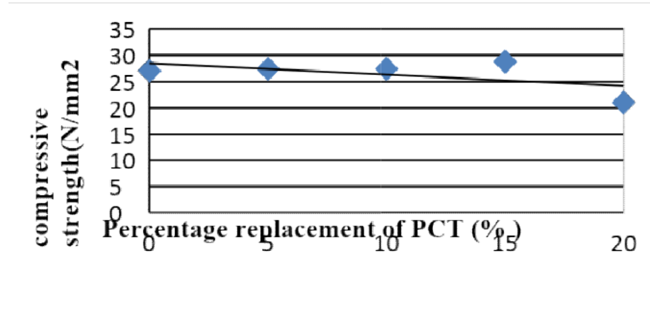


Figure 9: Regression analysis showing relationship showing between compressive strength at 28 days and percentage replacement of powdery ceramic tiles.

It was observed that the relationship has been obtained using polynomial regression analysis as F_{st} = -0.02146x + 28.484 with R^2 = 0.3107 which shows that there is fair relationship between compressive strength and percentage replacement of powdery ceramic tiles in concrete.

Table 5: Water absorption of specimen

% Repla	Weight (g) Before curing	After curing	% Water absorption
0%	8176	7966	2.10
5%	8120	8360	2.96
10%	7960	8070	1.38
15%	7820	7990	2.17
20%	7980	8130	1.87

It was observed that 5% powdery ceramics tile has the highest water absorption rate of 2.96% and 10% powdery ceramics tile has the lowest water absorption rate of 1.38%. It was shown that increase in powdery ceramics tile led to reduction in water absorption of concrete. The water absorption in PCTC is good according to concrete Society, United Kingdom, concrete quality is classified as good if the saturated water absorption is between 0.89% and 3%.

Costs and quantities Implication

The calculation was done based on 14.3kg of cement which is the quantity and cost saved in the batch weight.

Quantity saved

5% of powdery ceramic tiles = 0.715/14.3 x100 = 5%

10% of powdery ceramic tiles = 1.43/14.3 x100 = 10% 15% of powdery ceramic tiles = 2.145/14.3 x100 = 15%

Cost saved

14.3kg of cement cost #833

5% of powdery ceramic tiles = 5 / 100 x 833 = #41.65

10% of powdery ceramic tiles = 10 / 100 x 833 =

83.30

15% of powdery ceramic tiles = 15 /100 x8 33= # 124.95

Assuming a bag of cement is used,

A bag of cement in Nigeria is #2500.

The cost of cement that will be saved if 15% of ceramic is used

= 15/100 x2500= # 375

V. CONCLUSION

10% and 15% replacement of PCT have true slump of 4mm.Concrete containing 15% Powdery Ceramic Tiles produced maximum compressive strength of 28.77N/mm^2 at 28 days. Concrete with 5% to 20% replacement produced equal value of density of concrete which is 2400Kg/m^3, though 5% substitute of PCT in concrete has the highest density of 2477Kg/m^3 which deduced and concluded that PCTC (Powdery Ceramic Tiles Concrete) with 5 to 20% replacement of PCT (Powdery Ceramic Tiles) has its densities fall within $(2400 \pm 80) Kg / m^3$.Concrete with replacement of 5% powdery ceramics tile has the highest water absorption rate of 2.96% and 10% powdery ceramics tile has the lowest water absorption rate of 1.38%. There is much remarkable decrease in strength of concrete between 15% and 20% and up to 15% replacement of cement with powdery ceramic tiles in concrete is technically and economically feasible and viable. Powdery ceramic tiles concrete has increased durability performance.

ACKNOWLEDGMENTS

The author acknowledges the contribution of Olaitan Abideemi for data collection and Adeyinka A.O for technical assistance in laboratories.

REFERENCES

[1]. Adeala A & Omisande L.A. (2016). The Use Of Broken Ceramic Tiles As Partial Replacement Of Coarse Aggregates In Concrete. Repositioning Nigerian Techological Education In The 21st Century (pp. 10-14). Ilaro: K&T Commercial Enterprises, Ilaro,Ogun State.
[2]. ASTM.C 618 (2008). Specification for fly ash. America: America Society of testing and materials.
[3]. BS 12. (2000). Specification for Portland cement. London: British Standards Institution.
[4]. BS8110-1. (1997). The Structural Use of Concrete. London: British Standards Institution.
[5]. BS 813-2. (1995). Determination of water absorption of concrete. London: British Standards Institution.
[6]. BS 1377-2. (1990). Sieve analysis of dry sample. London: British Standards Institution.
[7]. BS 1881 - 102. (1983). Methods of determination of Slump. London: British Standards Institution.
[8]. BS 1881-114.(1983). Methods of determination of density. London: British Standards Institute.
[9]. BS 1881- 116 . (1983). Method for Determination of Compressive Strength of Concrete . London: British Standards Institute.
[10]. Balogun, M.O. (2009): "Introduction to properties of construction materials". All deals investment company limited, Dallas.
[11]. Hardik,P ,Arora N.K & Shraddha, R. (2015). Use of Ceramic Waste Powder in Cement Concrete. Journal for Innovative Research in Science & Technology, 91-97.
[12]. Krishna, R & Matheena, S. L. (2013). Use of Tiles Dust as partial replacement for cement in concrete. International Journal of Engineering Research and Technology, pg 2656 -2660.
[13]. Saswat H & Vikas S. (2016). Partial Replacement of Fine Aggregate with Ceramic and Demolition Waste in Rigid Pavement. International Journal of Innovative Research in Science,Engineering and Technology, 15141-15151.
[14]. Vikas, R & Gurtej, S.S . (2013). Effect of Partial Replacement of Fine and Coarse Aggregate (10mm) with Ceramic Waste on the Properties of Concrete. International Journal of Science and Research, 75-77.